

(“Agarwal”). The Examiner also indicates the changes made to Section 102(e) by the American Inventors Protection Act (AIPA) do not apply to the examination of the present application because the application was not “filed on or after November 29, 2000, or (2) voluntarily published.” The comment is in error since the present application was filed on August 31, 2000. Accordingly, the present application is subject to examination pursuant to Section 102(e) as amended by the AIPA.

Applicant’s invention exposes a conductive layer to an oxygen-inhibiting plasma or other gas, including nitrogen free gases, prior to the formation of the another layer or layers on the conductive layer to substantially reduce the association of oxygen with the conductive layer during formation of the other layer or layers. By reducing the amount of oxygen associated with the conductive layer, the electrical characteristics of a semiconductor device including the conductive layer and another conductive layer formed thereon are improved, as will be discussed in more detail below with reference to the disclosed embodiments of the invention. In order to help the Examiner appreciate certain distinctions between the pending claims and the subject matter of the applied reference, the disclosed embodiments of the invention will now be discussed in comparison to the applied reference. Specific distinctions between the pending claims and the applied reference will be discussed after the discussion of the disclosed embodiments and the applied reference. This discussion of the differences between the disclosed embodiments and applied reference does not define the scope or interpretation of any of the claims.

One embodiment of the present invention is discussed with reference to Figures 7-10 in which an interposing layer 52 such as a tungsten nitride layer 52 is formed between a conductive plug 46 formed in a via 44 and a conductive line material 48 formed in a trench or container 50. The tungsten nitride layer 52 enhances the electrical contact between the line material and the plug, promotes adhesion of the line material within the container 50, prevents or slows the diffusion of materials across the tungsten nitride layer boundary, or serves some other purpose. As previously described, the tungsten nitride layer 52 may associate with oxygen after it is formed and subsequent thermal processes may result in the formation of an oxide layer 54 formed between the tungsten nitride layer 52 and the line material 48. Because the oxide layer 54 is an insulator, this layer will adversely affect the electrical connection between the line

material 48 and the plug 46. By exposing the tungsten nitride layer 52 to an oxygen-inhibiting agent or a reducing atmosphere prior to formation of the line material 48, the thickness of the oxide layer 54 is reduced to a thickness of less than 10 angstroms or entirely eliminated as illustrated respectively in Figures 9 and 10. In this way, the conductive tungsten nitride layer 52 is exposed to an oxygen-inhibiting agent or reducing atmosphere prior to the line material 48 being formed on the conductive tungsten nitride layer to thereby reduce an ability of the conductive tungsten nitride layer to associate with oxygen. As described in the specification, the tungsten nitride layer 52 or other conductive layer may be treated in a plasma such as an N₂ and H₂ plasma, an NH₃ plasma, or an N₂ plasma. See page 6, lines 13-30 and page 7, lines 1-19. Furthermore, the conductive layer may be treated in a nitrogen-free gas, such as a plasma treatment including H₂, or may be treated with other materials such as diborane B₂H₆, phosphine PH₃, methylsilane CH₃SiH₃, hexamethyldisilane (CH₃)₃Si-Si(CH₃)₃, hexamethyldisilazane HMDS, carbon tetrafluoride CF₄, CHF₃, HCL, boron trichloride BCl₃, and silane SiH₄, and any combinations of these materials, as described on page 7, lines 25-30, page 8, lines 1-16, and page 9, lines 1-12.

The Agarwal patent discloses a method for passivating a dielectric layer 16 to form a passivation layer 18a thereon as shown in Figures 1A and 1B. The passivation layer 18a can be formed by annealing the dielectric layer 16 in a reactive environment composed of various gaseous materials, such as nitrogen, hydrogen, ammonia, hydrazine, monomethyl hydrazine, H₂ and N₂, carbon tetrafluoride, CHF₃, HCL, boron trichloride, and mixtures thereof, as described in Column 4, lines 49-62. The exposure of the dielectric layer 16 to the reactive atmosphere forms the passivation layer 18a to limit or stop oxygen, carbon, or other species from transporting between the dielectric layer and an upper electrode.

In another embodiment shown in Figures 2A and 2B, an electrically conductive lower electrode 14 is exposed to such a reactive environment to form a passivation layer 18b thereon and an insulating dielectric layer 16 then formed on the passivation layer 18b. The passivation layers 18a, 18b are electrically insulating layers, which is not a concern in Agarwal since a dielectric layer, which is another electrically insulating layer, is being formed on the passivation layer in either case. Thus, in Agarwal when the conductive lower electrode 14 is passivated the nonconductive passivation layer 18b is formed on the lower electrode, which is

fine since the dielectric layer 16 is then formed on the passivation layer. If another conductive layer was to be formed on the conductive lower electrode 14, however, the passivation layer 18b would inhibit electrical connection between the two conductive layers and form an unwanted capacitor corresponding to the electrode 14, layer 18b, and the other conductive layer. The passivation layer 18b would need to be removed to allow proper electrical connection between the electrode 14 and other conductive layer.

Amended claim 43 recites a method of passivating a multilayer conductive structure. The method includes layering a first conductive material and introducing the first conductive material to a material selected from the group consisting of diborane, phosphine, a carbon-silicon compound, HCL, and boron trichloride. Electromagnetic energy is applied to the material introduced to the first conductive material and a second conductive material is layered over the first conductive material. Agarwal neither discloses nor suggests introducing the first conductive material to a material selected from the group consisting of diborane, phosphine, a carbon-silicon compound, HCL, and boron trichloride, applying electromagnetic energy to the selected material, and layering a second conductive material over the first conductive material. The combination of elements recited in amended claim 43 is therefore allowable.

Amended claim 76 recites a method of passivating a multilayer conductive structure. The method includes layering a first conductive material and introducing the first conductive material to a material selected from the group consisting of phosphine and a carbon-silicon compound. Electromagnetic energy is applied to the material introduced to the first conductive material and a second conductive material is layered over the first conductive material. Agarwal neither discloses nor suggests introducing the first conductive material to a material selected from the group consisting phosphine and a carbon-silicon compound, applying electromagnetic energy to the selected material, and layering a second conductive material over the first conductive material. Accordingly, the combination of elements recited in amended claim 76 is allowable.

Amended claim 78 recites a method of passivating a multilayer conductive structure. The method includes layering a first conductive material and introducing the first conductive material to a material selected from the group consisting of phosphine and a carbon-silicon compound. A second conductive material is layered over the first conductive material.

The Agarwal patent neither discloses nor suggests introducing the first conductive material to a material selected from the group consisting phosphine and a carbon-silicon compound and layering a second conductive material over the first conductive material. The combination of elements recited in amended claim 78 is accordingly allowable.

The claims dependent on the independent claims are allowable for the same reasons as the independent claims, and because of the additional limitations added by the dependent claims. In addition, new claims 79 and 80 each recite the carbon-silicon compound in the corresponding independent claim being selected from the group consisting of methylsilane CH₃SiH₃, hexamethyldisilane (CH₃)₃Si-Si(CH₃)₃, and hexamethyldisilazane HMDS. Agarwal neither discloses nor suggests exposing a first conductive layer to the recited carbon-silicon compounds and then layering a second conductive layer on the first conductive layer. Dependent claims 79 and 80 are thus allowable for these additional reasons.

In the Office Action, the Examiner indicated that applicant's Information Disclosure Statement (IDS) filed February 4, 2002 failed to include copies of several cited references, and thus were not considered by the Examiner. No IDS was filed on February 4, 2002, but an IDS was filed on January 4, 2002, and the undersigned assumes it is this IDS to which the Examiner is referring. In response to the Examiner's comments, a new form PTO-1449 along with copies of these references accompanies this amendment. A complete copy of an IBM Technical Disclosure cited on the PTO-1449 is not included because the undersigned was not able to obtain a complete copy of this reference. The reference was cited by an Examiner in a related application and a summary of the article was provided to the undersigned. This is the only copy available without expending substantial client resources. A copy of the summary is again provided. Moreover, it should be noted that the Board of Patent Appeals and Interferences recently indicated in *Ex parte Jones*, 62 U.S.P.Q.2d 1206, 1209 (BPAI 2001) that the burden of obtaining translations of references "is the responsibility of the examiner." While this situation does not involve a translation, the rationale of the case applies to this situation as well and thus the Examiner appears in a better position than the applicant to obtain a copy of the IBM reference cited by another examiner at the patent office. The Examiner is requested to consider all the references cited in the accompanying PTO-1449.

The specification has been amended to include a patent number corresponding to an application number set forth in the specification. This amendment adds no new matter.

All pending claims are in condition for allowance, and favorable consideration and a Notice of Allowance are respectfully requested. The Examiner is requested to contact the undersigned at the number listed below for a telephone interview if, upon consideration of this amendment, the Examiner determines any pending claims are not in condition for allowance.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version with Markings to Show Changes Made".

Respectfully submitted,
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PFR:asw

Enclosures:

- Postcard
- Fee Transmittal Sheet (+ copy)
- Form PTO-1449 with Cited References (4)

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Paragraph beginning at line 4 of page 8 has been amended as follows:

Still other gases include diborane (B_2H_6); phosphine (PH_3); and carbon-silicon compounds such as methylsilane (CH_3SiH_3) and hexamethyldisilane ($(CH_3)_3Si-Si(CH_3)_3$); and hexamethyldisilazane (HMDS). Additional alternate embodiments of the current invention use hydrazine (N_2H_4), monomethylhydrazine, carbon tetrafluoride (CF_4), CHF_3 , HCl , and boron trichloride (BCl_3), which are also useful in passivating dielectrics, as addressed in copending application 09/114,847, now issued as U.S. Patent No. 6,201,276 B1. Also included are mixtures of any of the gases or types of gases described above. Exemplary non-plasma process parameters using these other gases include a flow rate of about 2 sccm to about 400 sccm for these gases; a flow rate of about 50 sccm to about 100 sccm for an inert carrier gas such as He or Ar; a temperature ranging from about 150 to about 600 degrees Celsius, a pressure ranging from about 50 millitorr to about 1 atmosphere (760 torr); and a process time ranging from about 50 to about 500 seconds. Again, one skilled in the art is aware that these parameters can be altered to achieve the same or a similar process.

In the Claims:

Claim 77 has been cancelled.

Claims 43, 44, 76, and 78 have been amended as follows:

43. (Twice Amended) A method of passivating a [multiplayer] multilayer conductive structure, comprising:

layering a first conductive material;

introducing [a selection of N_2/H_2 , N_2 , and NH_3 plasma to] said first conductive material to a material selected from the group consisting of diborane, phosphine, a carbon-silicon compound, HCL, and boron trichloride;

[releasing nitrogen from said plasma with] applying electromagnetic energy to the material introduced to the first conductive material; and

layering a second conductive material over said first conductive material.

44. (Twice Amended) The method in claim 43, wherein said step of [releasing nitrogen from said plasma with] applying electromagnetic energy to the material introduced to the first conductive material comprises directing ultraviolet light toward the material introduced to the first conductive material[said gas].

76. (Twice Amended) A method of passivating a multilayer conductive structure, comprising:

layering a first conductive material;

introducing [N₂ plasma to] said first conductive material to a material selected from the group consisting of phosphine and a carbon-silicon compound;

[releasing nitrogen from said plasma with] applying electromagnetic energy to the material introduced to the first conductive material; and

layering a second conductive material over said first conductive material.

78. (Amended) A method of passivating a [multiplayer] multilayer conductive structure, comprising:

layering a first conductive material;

introducing [a selection of CF₄, HCl, and BCl₃ gases to] the first conductive material to a material selected from the group consisting of phosphine and a carbon-silicon compound; and

layering a second conductive material over the first conductive material.